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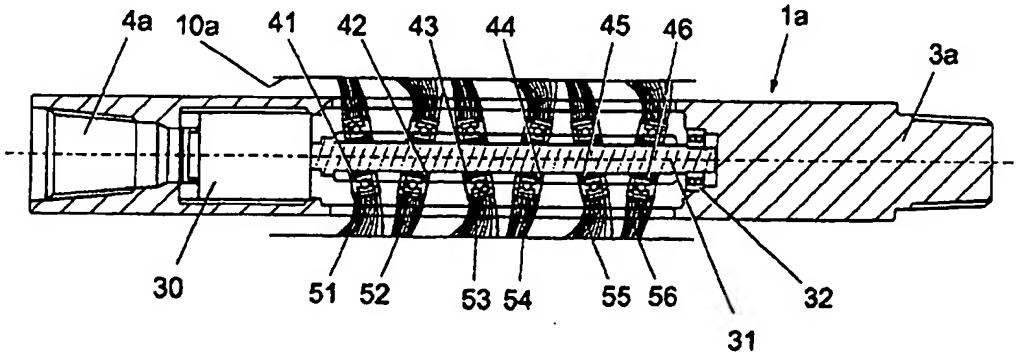
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(54) Title: TRACTION APPARATUS



(57) Abstract

A traction apparatus (1A) includes at least one traction member (51) which engages a surface (10A) against which traction is to be provided. The traction member can move relatively freely in one direction over the surface but has high resistance to movement in the other direction. The apparatus can be made to move by having a number of traction members (51-56) which move or oscillate relative to each other. There are preferably a large number of traction members which are in the forms of bristles in a brushlike part of the apparatus. The apparatus is suitable for use in down-hole tools. The bristles are bent in a first direction by being constrained in a hole facilitating movement in the opposite direction but preventing movement in the first direction.

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1 **TRACTION APPARATUS**

2

3 This invention relates to a traction apparatus and
4 especially but not exclusively to a traction apparatus
5 for use in a down hole tool which is adapted for
6 operation in horizontal wells or bores.

7

8 Within the oil and petroleum industry there is a
9 requirement to deploy and operate equipment along bores
10 in open formation hole, steel cased hole and through
11 tubular members such as marine risers and sub-sea
12 pipelines. In predominately vertical sections of well
13 bores and risers this is usually achieved by using
14 smaller diameter tubular members such as drill pipe,
15 jointed tubing or coiled tubing as a string on which to
16 hang the equipment. In many cases the use of steel
17 cable (wire line), with or without electric conductors
18 installed within it, is also common. All of these
19 approaches rely on gravity to provide a force which
20 assists in deploying the equipment.

21

22 In the case of marine pipe lines which are generally
23 horizontal, "pigs" which are basically pistons sealing
24 against the pipe wall, are used to deploy and operate
25 cleaning and inspection equipment, by hydraulically

1 pumping them along the pipe, normally in one direction.

2
3 Within the oil and petroleum industry to date the
4 requirement to deploy equipment has been fulfilled in
5 these ways.

6

7 However, as oil and gas reserves become scarcer or
8 depleted, methods for more efficient production are
9 being developed.

10

11 In recent years horizontal drilling has proved to
12 enhance greatly the rate of production from wells
13 producing in tight or depleted formation. Tight
14 formations typically are hydrocarbon-bearing formations
15 with poor permeability, such as the Austin Chalk in the
16 United States and the Danian chalk in the Danish Sector
17 of the North Sea.

18

19 In these tight formations oil production rates have
20 dropped rapidly when conventional wells have been
21 drilled. This is due to the small section of producing
22 formation open to the well bore.

23

24 However when the well bore has been drilled
25 horizontally through the oil producing zones, the
26 producing section of the hole is greatly extended
27 resulting in dramatic increases in production. This
28 has also proved to be effective in depleted formations
29 which have been produced for some years and have
30 dropped in production output.

31

32 However, horizontal drilling has many inherent
33 difficulties, a major one being that the forces of
34 gravity are no longer working in favour of deploying
35 and operating equipment within these long horizontal
36 bores.

1 This basic change in well geometry has led to
2 operations which normally could have been carried on
3 wire line in a cost effective way now being carried out
4 by the use of stiff tubulars to deploy equipment, for
5 example drill pipe and tubing conveyed logs which cost
6 significantly more than wire-line deployed logs.

7

8 Sub-sea and surface pipeline are also increasing in
9 length and complexity and pig technology does not fully
10 satisfy current and future needs. There is currently a
11 need for a traction apparatus which can be used
12 effectively in down-hole applications including
13 horizontal bores.

14

15 According to the present invention there is provided
16 traction apparatus comprising: a body from which body
17 extends at least one traction member wherein said at
18 least one traction member is adapted to be urged
19 against a traction surface against which traction is to
20 be obtained, and wherein when said at least one
21 traction member is urged against such a surface it is
22 adapted to move relatively freely in one direction with
23 respect to said surface, but substantially less freely
24 in the opposite direction.

25

26 Preferably, said at least one traction member is formed
27 from a resilient material.

28

29 Preferably, said at least one traction member includes
30 an end portion for contact with a traction surface.

31

32 Preferably, said body is elongate and said at least one
33 traction member is adapted to be inclined so that it
34 extends in a first axial direction of the body as it
35 extends between the body and a traction surface.

36

1 Preferably, the direction in which the traction member
2 is adapted to move preferentially is substantially
3 opposed to the first axial direction of the body.

4

5 Preferably, the system is for use in a bore and the
6 traction surface comprises the inner wall of the bore.

7

8 Preferably, there is provided means to move the at
9 least some portion of one or more of at least one
10 traction members with respect to the traction surface.

11

12 Preferably, said motion of the one or more traction
13 members allows propulsion of the body with respect to
14 the traction surface.

15

16 Preferably, said propulsion is substantially in the
17 direction in which the traction member moves
18 preferentially with respect to the traction surface.

19

20 Preferably, the motion of the one or more traction
21 members is provided by applying a force with a
22 component substantially parallel to the direction of
23 preferential movement of the at least one traction
24 member.

25

26 Preferably, the motion of the one or more traction
27 members is provided by applying a force with a
28 component substantially perpendicular to the direction
29 of preferential movement of the at least one traction
30 member.

31

32 Motion may be provided to the one or more traction
33 members by connection to a rotary member having a first
34 axis, which rotates about a second axis which is not
35 coincident with said first axis.

36

1 Preferably, said means to move the at least one
2 traction member comprises means to oscillate said at
3 least one traction member.

4

5 Preferably, there are provided a plurality of traction
6 members in close proximity to each other, to form a
7 discrete area of traction members.

8

9 Preferably, at least two of the traction members in
10 said discrete area are encapsulated together in a
11 matrix of resilient material.

12

13 Preferably, there are provided a number of spaced
14 apart, discrete areas of traction members.

15

16 Preferably, at least two discrete areas of traction
17 members are moved relative to each other.

18

19 Embodiments of the invention will now be described by
20 way of example, with reference to accompanying drawings
21 in which:

22

23 Fig. 1 shows an embodiment of traction apparatus
24 in accordance with the present invention
25 incorporated into a down-hole tool;

26

27 Fig. 2a is a schematic cross sectional view of an
28 alternative embodiment of the present invention,
29 which is hydraulically powered in use;

30

31 Fig. 2b is a graph showing hydraulic fluid
32 pressure versus time for the embodiment of Fig. 2a
33 in use;

34

35 Fig. 3 is a schematic cross sectional view of a
36 further alternative embodiment of the present

1 invention in use;

2
3 Fig. 4a is a schematic cross sectional view of a
4 detail of the embodiment of Fig. 3 with a
5 variation in configuration;

6
7 Fig. 4b is a schematic cross sectional view of
8 part of a further variation of the embodiment of
9 Fig. 3;

10
11 Fig. 4c is a cross sectional view showing a detail
12 of the embodiment of Fig. 4b;

13
14 Figs. 5a, 6a and 7a are schematic illustrations
15 showing side views of the sequential positions of
16 elements in a further embodiment of the present
17 invention in use;

18
19 Figs. 5b, 6b and 7b are schematic end views
20 corresponding to Figs. 5a, 6a and 7a,
21 respectively;

22
23 Figs. 8a and 8b show schematically embodiments of
24 brush sections suitable for use in embodiments of
25 apparatus in accordance with the present
26 invention; and

27
28 Figs. 9a and 9b show, respectively, a perspective
29 view and a cross sectional view of an embodiment
30 of a pig which includes traction members.

31
32 Fig. 1 shows an embodiment of traction apparatus
33 incorporated into a down-hole tool 1. The down-hole
34 tool comprises a body 2 which is elongate and which has
35 a threaded front end portion 3 and a threaded rear end
36 portion 4 to allow attachment into a tool string. (It

1 should be appreciated that the terms "front end" and
2 "rear end" are used for convenience only and should not
3 be considered limiting. Terms such as "in front" and
4 "rearwards", which will be used hereafter, are to be
5 understood accordingly.)

6

7 The tool body is provided with brush portions of which
8 three, designated 5a, 5b and 5c are shown. Each brush
9 portion 5a, 5b and 5c includes a number of brush
10 sections and each brush section includes a large number
11 of resilient bristles which in this embodiment comprise
12 traction members, and which extend outwardly from the
13 body 2. The bristles thus have inner ends attached to
14 the body and outer ends distal from the body.

15

16 If the down hole tool 1 is inserted front end first
17 into a bore with a diameter larger than the diameter of
18 the body 2 but slightly smaller than the external
19 diameter formed by the outer ends of the bristles, then
20 the bristles will be bent back, by the contact with the
21 inner wall of the bore, such that the outer ends of the
22 bristles are axially behind the inner ends of the
23 bristles. Under these circumstances the outer ends of
24 the bristles will contact the inner wall of the bore
25 and will offer more resistance to rearward motion of
26 the tool than to forward motion of the tool. The
27 bristles therefore move preferentially in the forward
28 direction as against the rearward direction. Preferred
29 embodiments of the present invention employ the
30 principle behind this phenomenon to allow propulsion of
31 a tool by providing relative movement or oscillation
32 between two or more brush sections (ie two or more
33 groups of bristles constituting traction members).

34

35 Fig. 2a shows schematically a preferred embodiment of
36 traction apparatus in accordance with the present

1 invention. The apparatus comprises first to fifth
2 sections 12a to 12e respectively.

3

4 The sections 12a to 12e are connected by a pipe 16
5 which carries hydraulic fluid. First to fourth
6 resilient members 17a to 17d are provided between the
7 first to fifth sections 12a to 12e.

8

9 The apparatus, as illustrated in Fig 2a is provided
10 within a horizontal bore which has an inner wall 10 the
11 surface of which constitutes a traction surface.

12

13 The second section 12b of the apparatus will now be
14 described in detail. The other sections 12a, 12c, 12d,
15 12e are similar in structure and function and will not
16 be separately described in detail.

17

18 The second section 12b includes a front portion 13
19 provided with a front brush section 18 and a rear
20 portion provided with a rear brush portion 19. The
21 brush portions 18, 19 are formed from resilient
22 bristles which are, in use, deformed by contact with
23 the inner wall 10 so that the outermost end of each
24 bristle is to the rear of the inner most end of the
25 bristle. The bristles thus constitute traction members
26 which are adapted to move preferentially in one
27 direction (to the right as shown in Fig. 2). The rear
28 portion 14 is fixed around the pipe 16, is co-axial
29 with the pipe 16, and includes a larger diameter part
30 14a and a smaller diameter part 14b. The smaller
31 diameter part 14b is forward of the larger diameter
32 part 14a. Where the diameter changes between the
33 larger diameter part 14a and the smaller diameter part
34 14b an abutment shoulder 14c is formed.

35

36 The front portion 13 is able to move axially with

1 respect to the pipe 16 and is sealed against the pipe
2 16 by a sliding seal 20. The front portion is cup
3 shaped having a base part 13a which contacts the pipe
4 16 and a cylindrical hollow part 13b, extending
5 rearward from the base part 13a, which is radially
6 spaced apart from the pipe 16.

7

8 The inner diameter of the hollow part 13b of the front
9 portion 13 is substantially the same as the outer
10 diameter of the smaller diameter part 14b of the rear
11 portion 14. The smaller diameter part 14b fits inside
12 the hollow part 13b and a sliding seal 15 is provided
13 therebetween. As the rear portion 14 is fixed with
14 respect to the pipe 16 and the front portion 13 is able
15 to move axially with respect to the pipe 16, the hollow
16 part 13b is able to move axially with respect to the
17 smaller diameter part 14b so as to cover more or less
18 of the smaller diameter part 14b.

19

20 The hollow part 13b has a longer axial length than the
21 smaller diameter part 14b so that when the smaller
22 diameter part 14b is completely covered by the hollow
23 part 13b the rearmost end of the hollow part 13b abuts
24 the abutment shoulder 14c but the forwardmost end of
25 the smaller diameter part 14b does not reach the base
26 part 13a of the front portion 13. A hydraulic fluid
27 space 21 is formed between the base part 13a and the
28 forwardmost end of the smaller diameter part 14b. A
29 hydraulic fluid outlet 22 from the pipe 16 is provided
30 to supply fluid to the hydraulic fluid space 21.

31

32 In use, the hydraulic fluid pressure in the pipe 16 is
33 increased to force fluid into the hydraulic fluid space
34 21. This forces apart the front portion 13 and the
35 rear portion 14. Since the front portion 13 is less
36 resistant to forward motion than the rear portion 14 is

1 to rearward motion (because of the action of the brush
2 portions 18, 19) this results in the front portion 13
3 being forced forward while the rear portion 14 stays
4 stationary. This results in axial lengthening of the
5 hydraulic fluid space 21 and compression of the second
6 resilient member 17b.

7

8 The hydraulic fluid pressure in the pipe 16 is then
9 reduced so that the front portion 13 and the rear
10 portion 14 are forced together by the action of the
11 resilient member 17b, forcing hydraulic fluid from the
12 hydraulic fluid space 21 via the outlet 22 into the
13 pipe 16. As the front portion 13 and the rear portion
14 are forced together the considerable resistance of
15 the front portion 13 to rearward motion ensures that
16 the front portion remains substantially stationary with
17 respect to the inner wall 10 of the bore, so the rear
18 portion is forced forwards with respect to the inner
19 wall 10.

20

21 Each cycle of increase and decrease of fluid pressure
22 in the pipe 16 therefore results in the apparatus
23 taking a "step" in the desired direction along the
24 bore. It should, of course, be appreciated that
25 although the above has been described with respect to
26 only one section 12b of the apparatus of Fig. 2a, the
27 other sections 12a, 12c, 12d, 12e respond similarly to
28 increases and decreases in fluid pressure. Fig. 2b
29 shows how fluid pressure may be varied with time in
30 order to obtain movement of the apparatus at a rate of
31 about two steps per second. (One PSI is equal to about
32 6.9×10^3 Pa.)

33

34 Fig. 3 shows an alternative embodiment of a down-hole
35 tool 1a including traction apparatus according to the
36 present invention suitable for use on an electric line.

1 •Fig. 4a schematically shows a detail of a variation of
2 the embodiment of Fig. 3. The embodiment is
3 illustrated as being within a horizontal bore with an
4 inner wall 10a. The down-hole tool 1a has a front end
5 portion 3a and a rear end portion 4a.

6

7 The tool 1a includes an electric motor 30 which drives
8 an axle 31 aligned axially along the centre of the tool
9 1a. The axle 31 extends axially from the motor and is
10 journaled at its end distal from the motor 30 in a
11 bearing 32.

12

13 Mounted on the axle 31, between the motor 30 and the
14 bearing 32 are first to sixth collars 41 to 46 which
15 are inclined, at an angle away from the normal, with
16 respect to the axis of rotation of the axle 30. First
17 to sixth annular brush portions 51 to 56 are mounted
18 respectively on the first to sixth collars 41 to 46 via
19 first to sixth annular bearings 61 to 66. For
20 conciseness only one the first of the collar-bearing-
21 brush assemblies will be described in detail, but it
22 will be appreciated that the other assemblies
23 correspond.

24

25 The collar 41 is fixed to an annular inner race 61a of
26 the bearing 61 which rotatably supports, via a
27 plurality of rolling members 61b, an annular outer race
28 61c of the bearing 61. Upon the outer race 61c of the
29 bearing 61 is fixed an annular base part 51a of the
30 brush portion 51, which supports a plurality of
31 bristles 51b of brush portion 51.

32

33 When the axle 31 is rotated by the motor 30 the first
34 collar rotates so that its leading edge rotates about
35 the axis of the axle 31. Because it is supported on
36 the bearing 61 the first brush section 51 is not caused

1 to rotate by the rotation of the first collar 61.
2 However, as the collar rotates, the base part 51a of
3 the brush section 51 is moved so that any given point
4 on the base part 51a is moved one cycle backwards and
5 forwards relative to the axle for each rotation of the
6 axle.

7

8 The bristles 51b of the first brush section 51 are thus
9 forced forwards and backwards, against the inner wall
10a. The bristles move preferentially in the forward
11 direction and thus provide little reaction force on the
12 tool when moved forward against the inner wall 10a. In
13 contrast, the bristles offer considerably more
14 resistance when forced in the rearwards direction and
15 thus provide considerable reaction force on the tool.
16 Rotation of the axle 31 thus provides a net forward
17 force to propel the tool in the forwards direction.

18

19 As illustrated in Figs 3 and 4a a number of brush
20 sections 51 to 56 are provided in order to provide
21 greater traction than would be afforded by any one of
22 the brush sections. It is preferable to have the brush
23 sections out of phase in order to distribute the thrust
24 circumferentially around the tool. In Fig. 3 each of
25 the brush sections is shown as being 180 degrees out of
26 phase with the adjacent brush sections, so that, as
27 shown, the uppermost parts of the second, fourth and
28 sixth brush sections 52, 54, 56 are forwardmost and the
29 lowest parts of the first third and fifth brush
30 sections 51, 53, 55 are forwardmost. In Fig. 4a a
31 different phase distribution is illustrated. In
32 particular the forwardmost part of the third brush
33 section 53 is the part which would extend furthest out
34 of the page (not shown), and the forwardmost part of
35 the fourth brush section 54 is the part which extends
36 furthest into the page. Thus in Fig. 4a each of the

1 brush sections 51 to 56 is 180 degrees out of phase
2 with a first one of its neighbours, but each brush
3 section which has two neighbours is also 90 degrees out
4 of phase with the second of its neighbours. Such an
5 arrangement can provide improved stability under
6 traction. It should be noted that in Fig. 4a, because
7 the planes of the third and fourth brush sections 53,
8 54 are not normal to the page, more of the base parts
9 53a, 54a and bristles 53b, 54b of the third and fourth
10 brush sections 53, 54 can be seen than of the other
11 brush sections.

12

13 Fig. 4b illustrates a variation of the embodiment of
14 Fig. 3. Fig. 4c shows in detail part of the embodiment
15 of Fig. 4b. As shown in Fig. 4b, first and second
16 brush sections 57, 58 are mounted to an axle 131 which
17 can be rotated by a motor 130.

18

19 The brush sections 57, 58 each include a base section
20 57a, 58a and bristles 57b, 58b for engaging the inner
21 wall 10a.

22

23 Mounted to the axle 131 are first and second collars
24 47, 48 corresponding generally to the collars 41 to 46
25 of the embodiment of Fig. 3. Attached to the collars
26 47, 48 are first and second annular bearings 67, 68,
27 corresponding generally to bearings 61 to 66 of the
28 embodiment of Fig. 3 and each including an annular
29 inner race 67a, 68a, rolling members 67b, 68b and an
30 annular outer race 67c, 68c. Attached to the
31 respective outer races 67c, 68c of the bearings 67, 68
32 are respective annular brush-base holders 67d, 68d,
33 each adapted to receive one or more brush base
34 sections. Thus the brush base sections 57a, 58a are
35 not attached directly to the bearing outer races 67c,
36 68c but are instead fitted into the brush base holders

1 67d, 68d facilitating replacement of the brushes 57,
2 58.

3

4 Unlike the collars 41 to 46 of Figs. 3 and 4a, in the
5 embodiment of Figs. 4b and 4c the collars 47, 48 are
6 mounted to the axle 131 by fixing pins 47a, 48a which
7 extend through respective holes 47b, 48b which pass
8 through the collars 47, 48 in a direction perpendicular
9 to the axle 131.

10

11 The embodiments of Figs 3 to 4c thus provide traction
12 apparatus in which traction, and corresponding motion,
13 is provided by moving different traction members
14 (bristles in this embodiment) which are rigidly
15 connected to each other (via the brush base parts) at
16 different velocities in the axial direction, at any
17 given time.

18

19 Figs. 5a, 5b, 6a, 6b, 7a and 7b illustrate the action
20 of a traction device in which axial motion is provided
21 by forcing traction members in a radial direction with
22 respect to a down-hole tool 1b.

23

24 A down-hole tool 1b is provided with first to eighth
25 brush sections of which, for clarity in the drawings,
26 the first and second 71, 72 are shown in each of Figs.
27 5a to 7b, the third and fourth 73, 74 are shown in
28 Figs. 5b, 6b and 7b only, the fifth and sixth are shown
29 in Figs. 5a, 6a and 7a only, and the seventh and eighth
30 are not shown.

31

32 Each of the brush sections 71 to 76 is attached to the
33 main body of the down-hole tool 1b by a respective arm
34 member 81 to 86 which is radially extendable away from
35 the main body of the tool 1b.

36

1 Figs. 5a and 5b show the positions of the arm members
2 81 to 86 and brush sections 71 to 76 in an inactive
3 position in which all of the arms 81 to 86 are in their
4 respective retracted positions and the outermost ends
5 of the brush sections 71 to 76 (that is the outermost
6 ends of the bristles) are in light contact with an
7 inner wall 10b of a horizontal bore.

8

9 Figs. 6a and 6b show the positions of the arm members
10 81 to 86 and brush sections 71 to 76 at a first stage
11 in a traction cycle. At this time the arms 81 to 84 of
12 the first to fourth brush sections 71 to 74 are fully
13 radially extended, forcing the bristles of the brush
14 sections 71 to 74 against the inner wall 10b. This
15 radial extension causes the brush sections 71 to 74 to
16 push against the inner wall 10b in the backwards
17 direction, which applies a reaction force in the
18 forwards direction (rightwards as shown in Figs. 5a,
19 6a, 7a) on the body of the tool 1b. The force will
20 tend to move the body of the tool in the forwards
21 direction. The broken lines in Figs. 6a to 7a
22 correspond to the positions of the brush sections 71 to
23 76 in Figs. 5a and 5b so that the forwards movement can
24 be appreciated. As shown in Fig. 6a, at this point of
25 the traction cycle the fifth and sixth arms 85, 86 and
26 seventh and eighth arms (not shown) remain in their
27 retracted position.

28

29 Figs. 7a and 7b show the positions of the arm members
30 81 to 86 and brush sections 71 to 76 at a second point
31 in the traction cycle. At this time the fifth and
32 sixth arms 85 and 86 and the sixth and seventh arms
33 (not shown) are fully radially extended forcing the
34 fifth and sixth brush sections 75, 76 and the seventh
35 and eighth brush sections (not shown) against the inner
36 wall 10b. As in the case of the first to fourth brush

1 sections 71 to 74, described above, this applies a
2 force and corresponding movement to the body of the
3 tool 1a in the forwards (rightwards) direction. The
4 first to fourth arms retract as the fifth to eighth
5 arms extend so that, as shown in Figs. 7a and 7b the
6 first to fourth arms are fully restricted when the
7 fifth to eighth arms are fully extended.

8

9 Continuous cycling between the position shown in Fig.s
10 6a, 6b and the position shown in Figs. 7a, 7b will
11 provide a continued propulsive force on the body of the
12 tool 1a. Embodiments are envisaged in which traction
13 members may be moved both axially and radially and
14 either the axial or radial movement might predominate.

15

16 One of many driving mechanisms may be used to extend
17 and retract the arms 81 to 86. For example, mechanical
18 means such as a rotating shaft with four-lobed cams
19 could be used. Alternatively, a hydraulic system could
20 be employed. As a further alternative an electro-
21 mechanical system could be used. It will also be
22 appreciated that these and other driving mechanisms
23 could be suitable for driving the motion of the
24 traction members in the other embodiments of the
25 invention.

26

27 It will be appreciated that in certain embodiments of
28 the present invention the traction members will, in
29 equilibrium (that is when not contacting a traction
30 surface) be substantially perpendicular to the axis of
31 the traction apparatus. In such embodiments it is the
32 constriction of the traction members which effectively
33 sets the preferential direction of motion. In such
34 embodiments it may be possible to reverse the
35 preferential direction of motion by overpulling the
36 tool, ie by providing a sharp or jarring force. In

1 other embodiments it may be more appropriate to reverse
2 the preferential direction by retracting and re-
3 deploying the traction members.

4

5 It will be appreciated that although the preferred
6 embodiments described herein are disclosed as including
7 brushes in which the bristles constitute traction
8 members, other types of traction members may be used
9 provided they are able to contact the traction surface
10 and, when in contact, move preferentially in one
11 direction over the other. It is preferred that the
12 traction members are resilient elongate members, such
13 as leaf springs or bristles. In the case of bristles
14 it is preferred that the bristles be encapsulated into
15 a block of resilient material in order to reduce wear.

16

17 Figs. 8a and 8b show embodiments of first and second
18 brush section 180a, 180b, respectively.

19

20 Fig. 8a shows a round brush section 180a having a
21 number of bristles 182a encapsulated in a matrix 184a
22 of urethane or other suitably resilient material. The
23 bristles 182a are supported in a brush base section
24 186a comprising a generally cylindrical metal casing
25 for holding the bristle bases. A threaded connection
26 portion 188a is provided facilitating easy fitting and
27 replacement. Other types of connection could, of
28 course, be used. In this embodiment only the bristle
29 tips are uncovered by the matrix 184a.

30

31 Fig. 8b shows a rectangular brush section 180b having a
32 number of bristles 182b encapsulated in a rubber matrix
33 184b. The bristles 182b are supported in a brush base
34 186b which consists of a block of foundation material.
35 A connection portion 188b is provided. In this
36 embodiment a predetermined length of the bristles 182b

1 extends from the outer end of the rubber matrix 184b.

2
3 The contact of the traction members on the traction
4 surface is important in order to obtain preferential
5 movement in one direction. In preferred embodiments it
6 is desirable that the ends or tips of the traction
7 members engage the traction surface. The length of the
8 traction members is therefore important, since if a
9 traction member is too short it might not reach the
10 traction surface, and if the traction member is too
11 long it might be an axial surface of the traction
12 member, rather than the tip of the traction member,
13 which engages the traction surface. In practice, for
14 many types of traction member, a range of lengths
15 provide an acceptable result. Choice of length may be
16 of particular importance in embodiments such as those
17 of Figs. 3 to 7b in which the distance between the
18 innermost end of the traction member and the traction
19 surface varies during operation of the apparatus. It
20 is desirable that an effective length of traction
21 member is maintained at all times.

22

23 It should be appreciated that the distribution of the
24 traction members may be varied according to the
25 circumstances. It is desirable, but not essential, to
26 have traction members diametrically opposed on the
27 apparatus in order to maintain good stability.
28 Traction members may (or groups of traction members)
29 may be axially or circumferentially spaced as desired.
30 The number and properties of the traction members may
31 also be varied according to the circumstances.

32

33 Figs. 9a and 9b show a pig 90 including bristles 92
34 encapsulated in a matrix 94. The bristles 92 are set
35 into an annular bristle base 96 made of a foundation
36 material, in an inclined manner. Outer tips 92a of the

1 bristles 92 extend out of the matrix 94 for engaging
2 the inner wall 10a.

3

4 In use, the pig 90 can be moved to a desired position,
5 for example on a drill string, by application of
6 continuous fluid or gas pressure on the rearward side
7 (the leftward side as shown in Fig. 9b). When the
8 progress of the pig is impeded such that the continuous
9 pressure is insufficient to move the pig in the desired
10 direction, the pig can be oscillated in order to
11 provide traction because of the preferential motion of
12 the bristle tips 92a against the wall 10a in the
13 forward direction.

14

15 Modifications and improvements may be incorporated
16 without departing from the scope of the invention.

17

18

1 CLAIMS

- 2
- 3 1. A traction apparatus comprising: a body from which
4 body extends at least one traction member wherein
5 said at least one traction member is adapted to be
6 urged against a traction surface against which
7 traction is to be obtained, and wherein when said
8 at least one traction member is urged against such
9 a surface it is adapted to move relatively freely
10 in one direction with respect to said surface, but
11 substantially less freely in the opposite
12 direction.
- 13
- 14 2. A traction apparatus as claimed in Claim 1 wherein
15 said at least one traction member is formed from a
16 resilient material.
- 17
- 18 3. A traction apparatus as claimed in either
19 preceding claim wherein said at least one traction
20 member includes an end portion for contact with a
21 traction surface.
- 22
- 23 4. A traction apparatus as claimed in any preceding
24 claim wherein said body is elongate and wherein
25 said at least one traction member is adapted to be
26 inclined so that it extends in a first axial
27 direction of the body as it extends between the
28 body and a traction surface.
- 29
- 30 5. A traction apparatus as claimed in Claim 4 wherein
31 the direction in which the traction member is
32 adapted to move preferentially is substantially
33 opposed to the first axial direction of the body.
- 34
- 35 6. A traction apparatus as claimed in any preceding
36 claim wherein the system is for use in a bore and

1 the traction surface comprises the inner wall of
2 the bore.

3

4 7. A traction apparatus as claimed in any preceding
5 claim wherein there is provided means to move the
6 at least some portion of one or more of at least
7 one traction members with respect to the traction
8 surface.

9

10 8. A traction apparatus as claimed in Claim 7 wherein
11 said motion of the one or more traction members
12 allows propulsion of the body with respect to the
13 traction surface.

14

15 9. A traction apparatus as claimed in Claim 8 wherein
16 said propulsion is substantially in the direction
17 in which the traction member moves preferentially
18 with respect to the traction surface.

19

20 10. A traction apparatus as claimed in any of Claims 7
21 to 9 wherein the motion of the one or more
22 traction members is provided by applying a force
23 with a component substantially parallel to the
24 direction of preferential movement of the at least
25 one traction member.

26

27 11. A traction apparatus as claimed in any of Claims 7
28 to 10 wherein the motion of the one or more
29 traction members is provided by applying a force
30 with a component substantially perpendicular to
31 the direction of preferential movement of the at
32 least one traction member.

33

34 12. A traction apparatus as claimed in any of claims 7
35 to 11 wherein motion is provided to the one or
36 more traction members by connection to a rotary

1 member having a first axis, which rotates about a
2 second axis which is not coincident with said
3 first axis.

4

5 13. A traction apparatus as claimed in any of Claims 7
6 to 12 wherein said means to move the at least one
7 traction member comprises means to oscillate said
8 at least one traction member.

9

10 14. A traction apparatus as claimed in any preceding
11 claim wherein there are provided a plurality of
12 traction members in close proximity to each other,
13 to form a discrete area of traction members.

14

15 15. A traction apparatus as claimed in Claim 14
16 wherein at least two of the traction members in
17 said discrete area are encapsulated together in a
18 matrix of resilient material.

19

20 16. A traction apparatus as claimed in either of
21 Claims 14 or 15 wherein there are provided a
22 number of spaced apart, discrete areas of traction
23 members.

24

25 17. A traction apparatus as claimed in Claim 16
26 wherein at least two discrete areas of traction
27 members are moved relative to each other.

28

29

1 / 9

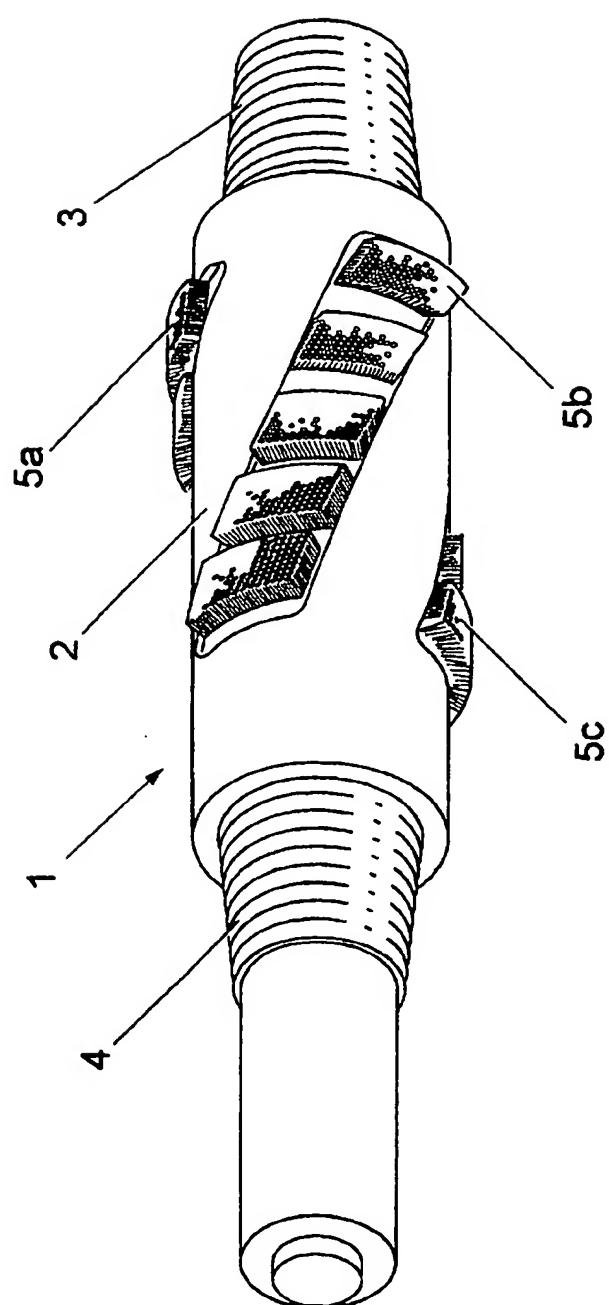
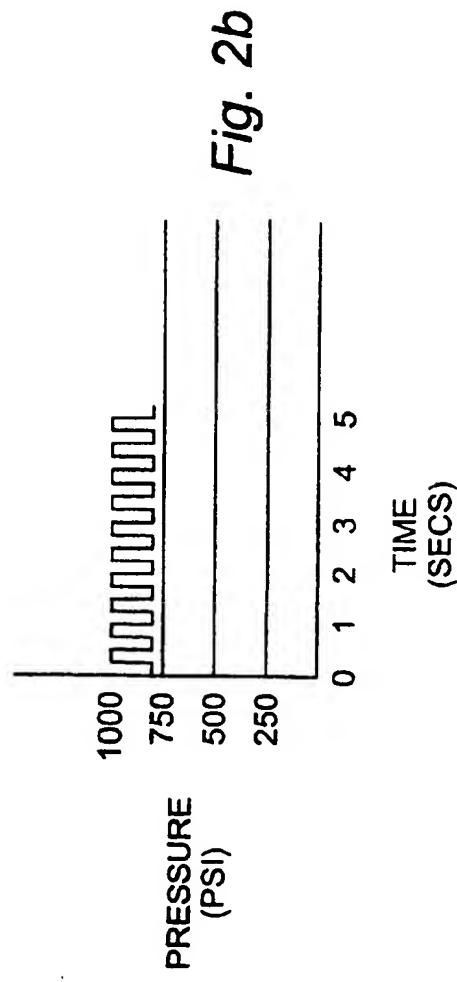
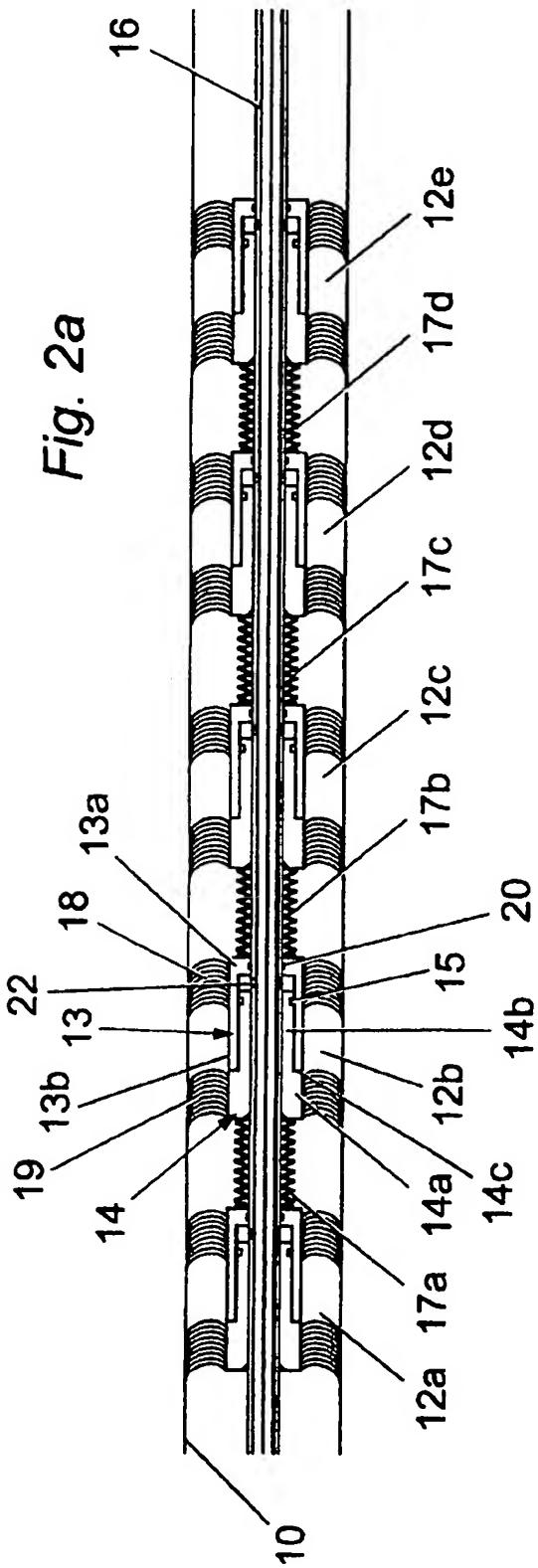


Fig. 1

2 / 9



3 / 9

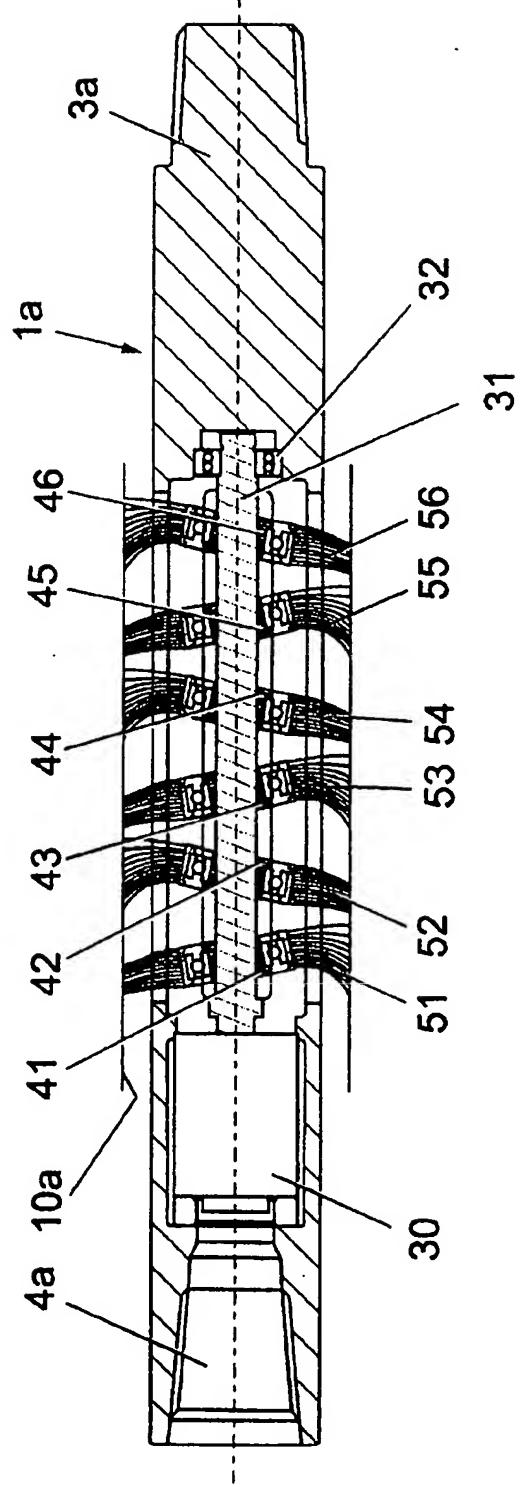


Fig. 3

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4 / 9

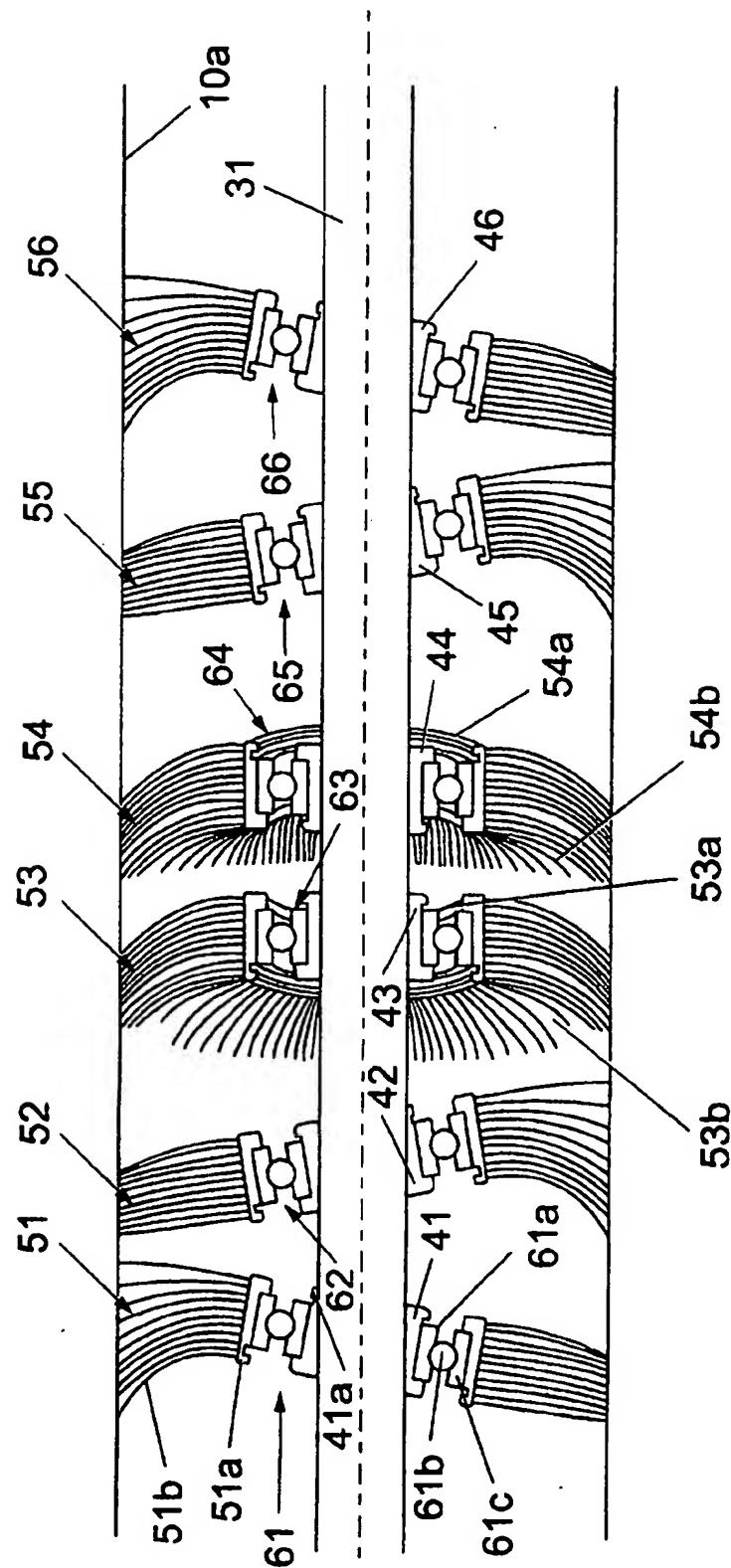


Fig. 4a

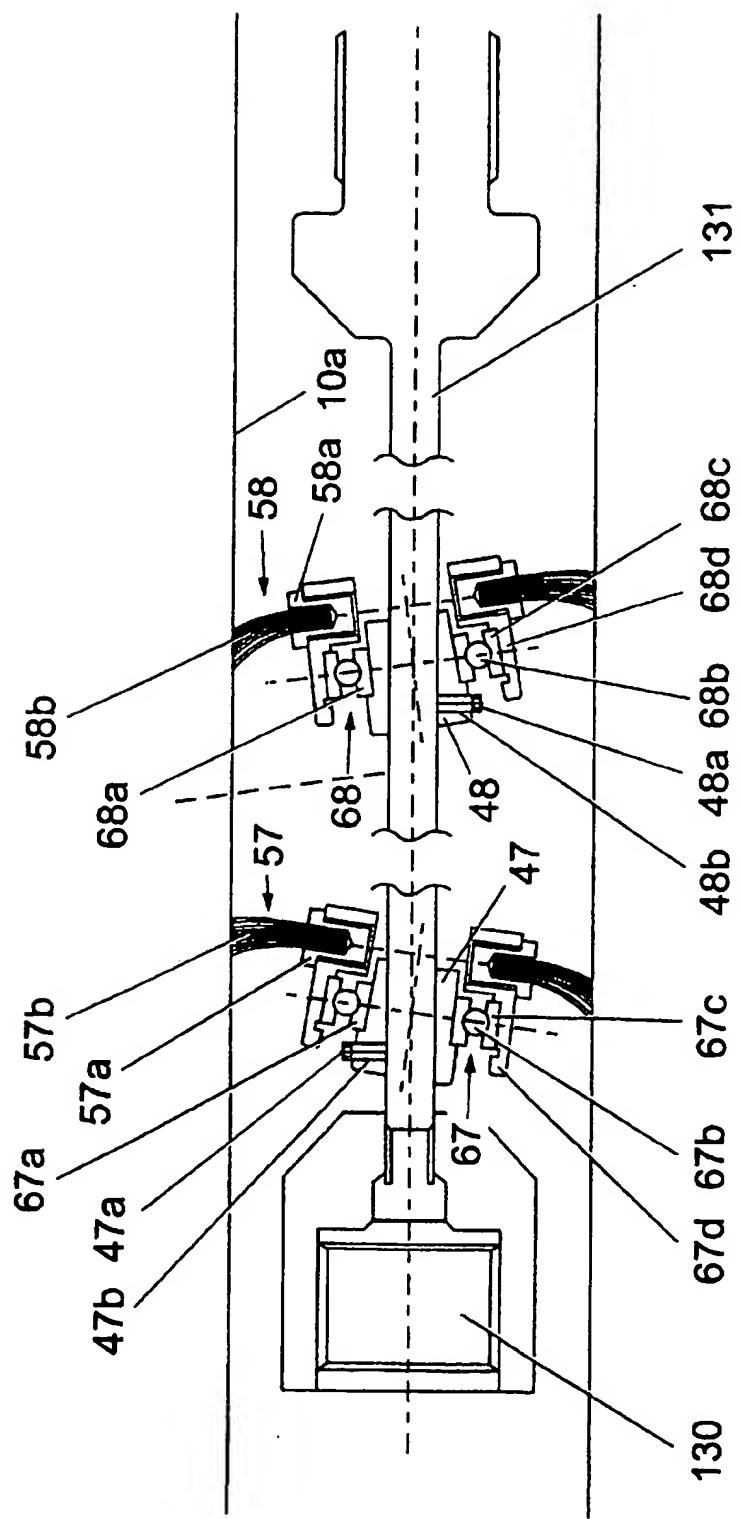


Fig. 4b

6 / 9

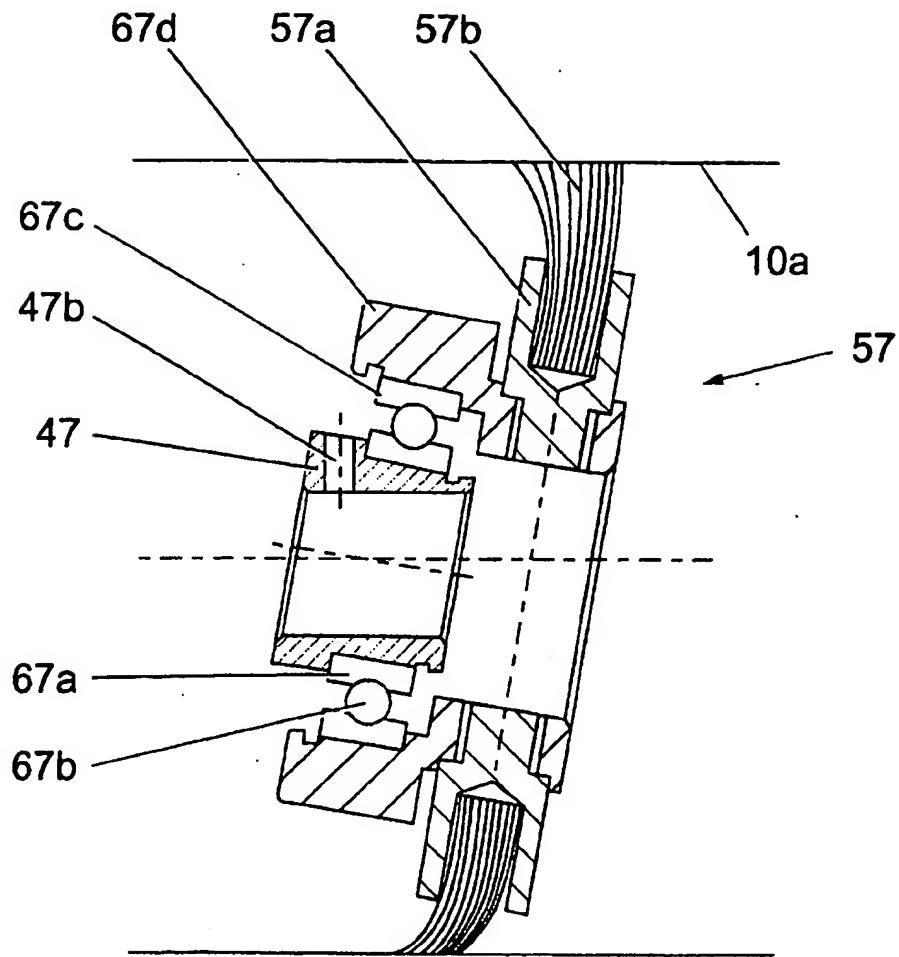


Fig. 4c

SUBSTITUTE SHEET (RULE 26)

7 / 9

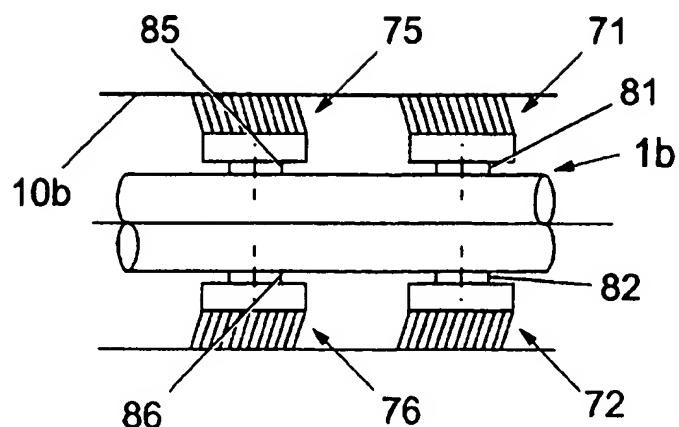


Fig. 5a

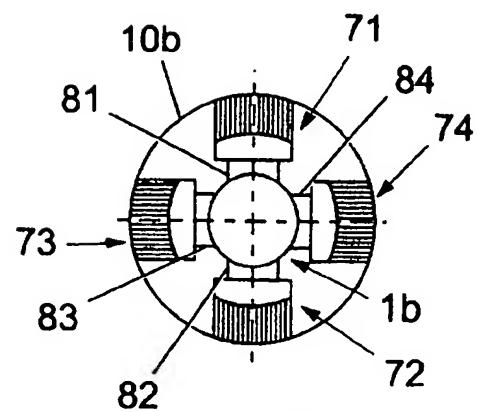


Fig. 5b

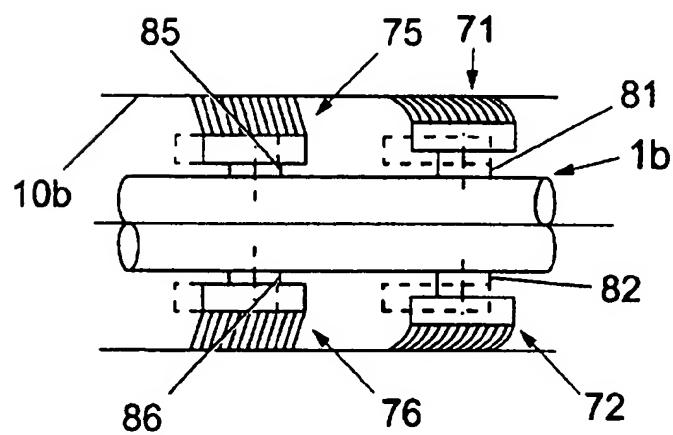


Fig. 6a

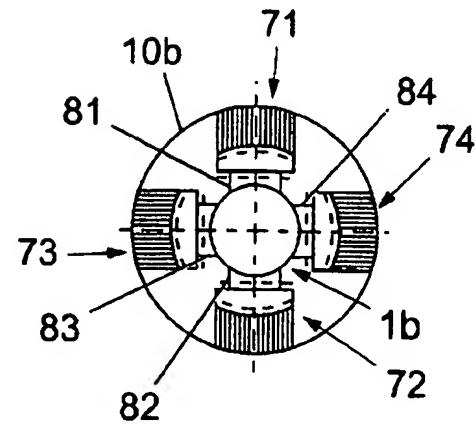


Fig. 6b

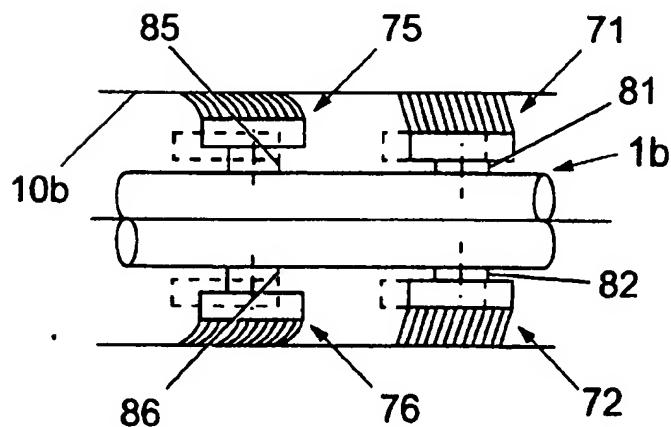


Fig. 7a

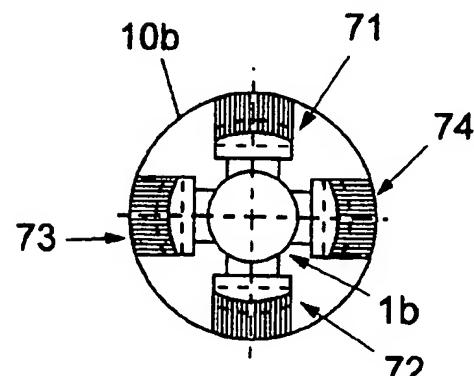


Fig. 7b

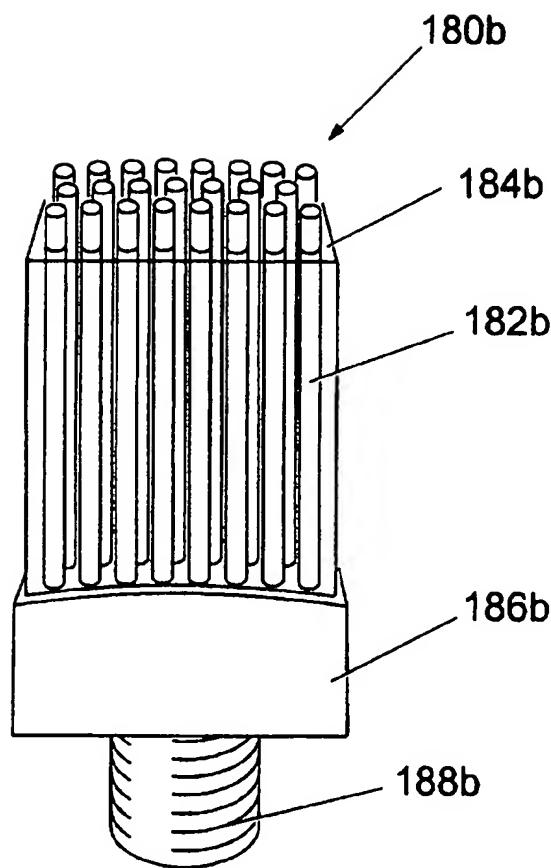
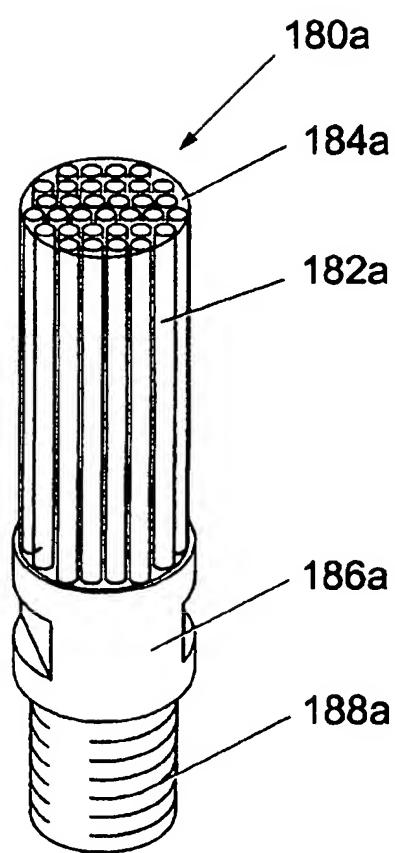


Fig. 8a

Fig. 8b

9 / 9

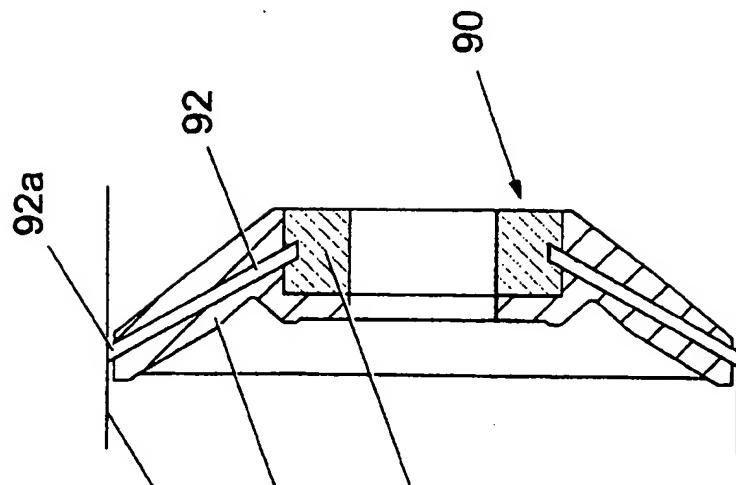


Fig. 9b

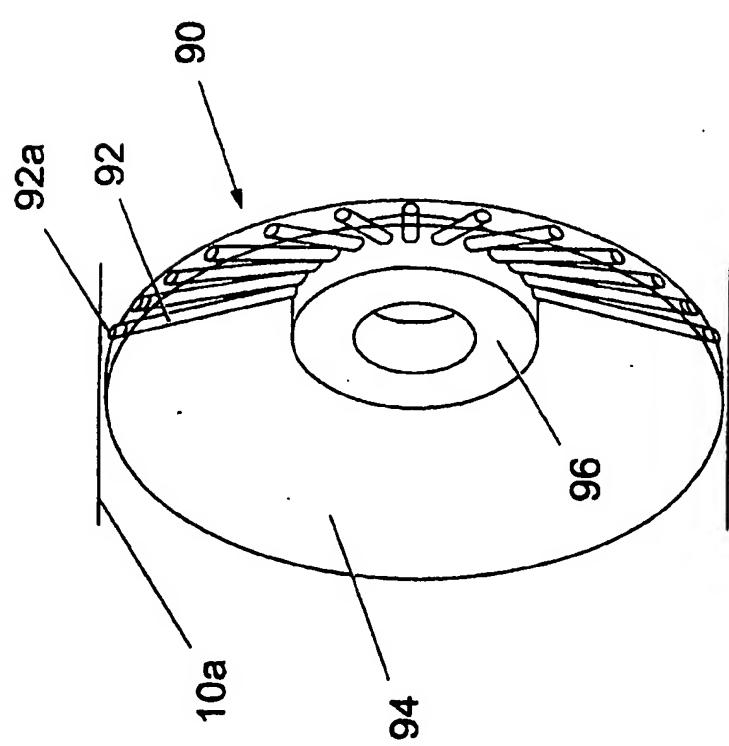


Fig. 9a

INTERNATIONAL SEARCH REPORT

PCT/GB 97/02188

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 E21B23/14 E21B23/08 F16L55/26

According to International Patent Classification(IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 E21B F16L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 389 208 A (LEVEEN ROBERT F ET AL) 21 June 1983 see column 2, line 62 - column 5, line 27 see figures 1-7 ---	1-10, 14, 16, 17
X	WO 94 08728 A (EKLUND BROR) 28 April 1994 see page 5, paragraph 2 see page 9, paragraph 3 see claims 5-8 see figures 3,4,7 ---	1-10, 12-14, 16
X	DE 33 11 094 A (BARTH HANS) 27 September 1984 see page 9 - page 13, paragraph 2 see figures 3-5 ---	1-10, 14, 16, 17 -/-

 Further documents are listed in the continuation of box C. Patent family members are listed in annex.

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1 Date of the actual completion of the international search

17 November 1997

Date of mailing of the international search report

28/11/1997

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Authorized officer

Schouten, A

INTERNATIONAL SEARCH REPORT

WILSON Application No.

PCT/GB 97/02188

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 144 240 A (E.L. CONNEL) 11 August 1964 see column 2, line 15-56 see column 4, line 4-45 see figures 1-11 ---	1-9,11, 13-16
X	US 4 071 086 A (BENNETT JOHN D) 31 January 1978 see column 1, line 36 - column 2, line 12 see column 2, line 29 - column 4, line 59 see figures 1-5 ---	1-10,14
X	US 4 031 750 A (YOUNMANS ARTHUR H ET AL) 28 June 1977 see column 2, line 44 - column 4, line 55 see figures 2-5 ---	1-10,13, 14
X	US 4 676 310 A (SCHERBATSKOY SERGE A ET AL) 30 June 1987 see column 8, line 8 - column 10, line 50 see figures 2-4 ---	1-10,14, 15
A	US 4 192 380 A (SMITH JOHN R E) 11 March 1980 see column 4, line 9 - column 5, line 25 see figures 3-5 -----	1

INTERNATIONAL SEARCH REPORT

PCT/GB 97/02188

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4389208 A	21-06-83	NONE	
WO 9408728 A	28-04-94	SE 470488 B AU 5289093 A EP 0768924 A NO 951373 A SE 9202980 A	30-05-94 09-05-94 23-04-97 30-05-95 10-04-94
DE 3311094 A	27-09-84	NONE	
US 3144240 A	11-08-64	NONE	
US 4071086 A	31-01-78	NONE	
US 4031750 A	28-06-77	CA 1074693 A DE 2735906 A DK 356377 A GB 1559442 A NL 7708360 A	01-04-80 09-03-78 03-03-78 16-01-80 06-03-78
US 4676310 A	30-06-87	NONE	
US 4192380 A	11-03-80	NONE	